

THAT WHICH IS CLAIMED:

1. A microelectromechanical device comprising:
a microelectronic substrate;
5 a thermally actuated microactuator disposed on said substrate and
comprised of a single crystalline material; and
at least one metallic structure disposed on said substrate and spaced from
said microactuator, wherein said microactuator is adapted to
operably contact said at least one metallic structure in response to
10 thermal actuation thereof.
2. A microelectromechanical device according to Claim 1 wherein said at
least one metallic structure comprises two metallic structures.
- 15 3. A microelectromechanical device according to Claim 1 wherein at least
one metallic structure is engaged and moved by said microactuator upon thermal
actuation thereof.
- 20 4. A microelectromechanical device according to Claim 1 wherein said at
least one metallic structure comprises a plurality of metallic structures, wherein at least
one of the plurality of metallic structure is movable such that thermal actuation of said
microactuator brings said microactuator into operable contact with the moveable metallic
structure, thereby allowing the moveable metallic structure to contact at least one of the
plurality of metallic structures such that metallic structures may be selectively brought
25 into contact in response to thermal actuation of said microactuator.

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5. A microelectromechanical device according to Claim 1 wherein the microelectromechanical device is a relay, and wherein said at least one metallic structure comprises two metallic structures, wherein one metallic structure is fixed and the other metallic structure is movable such that thermal actuation of said microactuator brings said microactuator into operable contact with the moveable metallic structure, thereby allowing the moveable metallic structure to contact the fixed metallic structure such that the metallic structures may be selectively brought into contact in response to thermal actuation of said microactuator.

6. A microelectromechanical device according to Claim 1 wherein the microactuator further comprises:
spaced apart supports disposed on said substrate;
at least one arched beam extending between said spaced apart supports;
an actuator member operably coupled to said at least one arched beam and extending outwardly therefrom; and
means for heating said at least one arched beam to cause further arching thereof such that said actuator member moves between a first position in which said actuator member is spaced apart from said at least one metallic structure and a second position in which said actuator member operably engages said at least one metallic structure.

7. A microelectromechanical device according to Claim 1 wherein said microactuator is thermally activated by internal heating thereof.

8. A microelectromechanical device according to Claim 1 wherein said microactuator is thermally activated by external heating thereof.

9. A microelectromechanical device according to Claim 1 wherein said microactuator comprises a plurality of arched beams coupled together.

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10. A microelectromechanical device according to Claim 1 wherein said microactuator is comprised of single crystal silicon.

11. A microelectromechanical device according to Claim 1 wherein said at least one metallic structure is comprised at least one of nickel and gold.

12. A method of fabricating a microelectromechanical structure having components formed of a single crystalline material and components formed of a metallic material, said method comprising the steps of:

10 forming a microactuator from a wafer comprised of a single crystalline material;
forming at least one metallic structure upon a first major surface of a substrate such that the metallic structure is movable relative to the substrate; and
15 bonding the microactuator upon the first major surface of the substrate following said forming steps such that portions of the microactuator are movable relative to the substrate in order to operably engage the metallic structure in response to actuation thereof.

13. A method according to Claim 12 wherein the step of forming a microactuator further comprises forming at least one of a thermally actuated microactuator and an electrostatic actuator.

14. A method according to Claim 12 wherein the step of forming a microactuator further comprises forming the microactuator from a single crystalline silicon wafer.

15. A method according to Claim 12 wherein the step of forming a microactuator comprises depositing a photoresist layer on the wafer, patterning the photoresist such that the photoresist which remains defines the microactuator, and etching the wafer to form the microactuator.

5 16. A method according to Claim 12 wherein the step of forming said at least one metallic structure comprises depositing a sacrificial plating base on a substrate, depositing a photoresist on the plating base, patterning the photoresist to open at least one window to the plating base defining the shape of said at least one metallic structure, and
10 electroplating metal within said at least one window to form said at least one metallic structure.

15 17. A method according to Claim 12 wherein the step of forming at least one metallic structure further comprises forming said at least one metallic structure from nickel.

20 18. A method according to Claim 12 wherein the bonding step further comprises bonding the microactuator to the substrate using a low temperature bonding process further comprising at least one of a eutectic bonding process and an anodic bonding process.

25 19. A method of fabricating a microelectromechanical structure having components formed of a single crystalline material and components formed of a metallic material, said method comprising the steps of:

bonding a wafer comprised of a single crystalline material upon a first major surface of a substrate;
defining at least one window through the wafer;
forming at least one metallic structure within said at least one window defined by the wafer; and

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forming a microactuator from the wafer following said bonding step such that portions of the microactuator are movable relative to the substrate in order to operably engage the metallic structure in response to actuation thereof.

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20. A method according to Claim 19 further including the step of depositing a sacrificial plating base on the surface of the substrate prior to the bonding step.

10 21. A method according to Claim 19 wherein the bonding step further comprises bonding a single crystalline silicon wafer upon a first major surface of a substrate.

15 22. A method according to Claim 19 wherein the bonding step further comprises bonding the microactuator to the substrate using a low temperature bonding process further comprising at least one of a eutectic bonding process and an anodic bonding process.

20 23. A method according to Claim 19 wherein the defining step further comprises depositing a photoresist layer on the wafer, patterning the photoresist to open at least one window to the wafer defining the shape of the at least one metallic structure, and etching the wafer to expose the plating base through said at least one window.

25 24. A method according to Claim 19 wherein the step of forming at least one metallic structure comprises electroplating metal within said at least one window in the wafer to form said at least one metallic structure.

25 25. A method according to Claim 19 wherein the step of forming at least one metallic structure comprises forming said at least one metallic structure from nickel.

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26. A method according to Claim 19 wherein the step of forming a microactuator further comprises forming at least one of a thermally actuated microactuator and an electrostatic actuator.

27. A method according to Claim 19 wherein the step of forming a microactuator further comprises depositing a photoresist layer on the wafer, patterning the photoresist such that the photoresist which remains defines the microactuator, and etching the wafer to form the microactuator.

28. A method of fabricating a microelectromechanical structure having components formed of a single crystalline material and components formed of a metallic material, said method comprising the steps of:

bonding a wafer comprised of a single crystalline material upon a first major surface of a substrate;

forming at least one metallic structure upon the first major surface of the substrate following said bonding step such that the metallic structure is movable relative to the substrate; and

forming a microactuator from the wafer following said bonding step such that portions of the microactuator are movable relative to the substrate in order to operably engage the metallic structure in response to actuation thereof.

29. A method according to Claim 28 wherein the bonding step further comprises bonding the microactuator to the substrate using at least one of a eutectic bonding process, an anodic bonding process, and a fusion bonding process.

30. A method according to Claim 28 wherein the bonding step further comprises bonding a single crystalline silicon wafer upon the first major surface of the substrate.

31. A method according to Claim 28 wherein the step of forming at least one metallic structure comprises depositing a sacrificial plating base on the substrate, depositing a photoresist on the plating base, patterning the photoresist to open at least one window to the plating base defining the shape of said at least one metallic structure, and electroplating metal within said at least one window to form said at least one metallic structure.

32. A method according to Claim 28 wherein the step of forming at least one metallic structure further comprises forming said at least one metallic structure from nickel.

33. A method according to Claim 28 wherein the step of forming a microactuator further comprises forming at least one of a thermally actuated microactuator and an electrostatic actuator.

34. A method according to Claim 28 wherein the step of forming a microactuator comprises depositing a photoresist layer on the wafer, patterning the photoresist such that the photoresist which remains defines the microactuator, and etching the wafer to form the microactuator.

35. A microelectromechanical device comprising:
a microelectronic substrate;
a microactuator disposed on said substrate and comprised of a single crystalline material; and
at least one metallic structure disposed on said substrate adjacent said microactuator and on substantially the same plane, wherein said microactuator is adapted to operably contact said at least one metallic structure in response to actuation thereof.

36. A microelectromechanical device according to Claim 35 wherein the microactuator is at least one of a thermally actuated microactuator and an electrostatic microactuator.

5 37. A microelectromechanical device according to Claim 35 wherein at least one metallic structure is engaged and moved by said microactuator upon actuation thereof.

10 38. A microelectromechanical device according to Claim 35 wherein said at least one metallic structure comprises a plurality of metallic structures, wherein at least one of the plurality of metallic structure is movable such that actuation of said microactuator brings said microactuator into operable contact with the moveable metallic structure, thereby allowing the moveable metallic structure to contact at least one of the plurality of metallic structures such that metallic structures may be selectively brought
15 into contact in response to actuation of said microactuator.

20 39. A microelectromechanical device according to Claim 35 wherein the microelectromechanical device is a relay, and wherein said at least one metallic structure comprises two metallic structures, wherein one metallic structure is fixed and the other metallic structure is movable such that actuation of said microactuator brings said microactuator into operable contact with the moveable metallic structure, thereby allowing the moveable metallic structure to contact the fixed metallic structure such that the metallic structures may be selectively brought into contact in response to actuation of said microactuator.

25 40. A microelectromechanical device according to Claim 35 wherein the microactuator further comprises:

spaced apart supports disposed on said substrate;

at least one arched beam extending between said spaced apart supports;

30 an actuator member operably coupled to said at least one arched beam and extending outwardly therefrom; and

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means for heating said at least one arched beam to cause further arching thereof such that said actuator member moves between a first position in which said actuator member is spaced apart from said at least one metallic structure and a second position in which said actuator member operably engages said at least one metallic structure.

41. A microelectromechanical device according to Claim 35 wherein the microactuator further comprises:

- at least one stator having a plurality of fingers protruding therefrom and disposed on said substrate;
- at least one shuttle disposed adjacent the stator and movable with respect thereto, the shuttle having a plurality of fingers protruding therefrom, the fingers being interdigitated with the fingers protruding from the stator;
- at least one support disposed on the substrate;
- an actuator member operably coupled to said at least one shuttle and said at least one support; and

means for electrically biasing said at least one stator with respect to said at least one shuttle to cause movement of the shuttle such that said actuator member moves between a first position in which said actuator member is spaced apart from said at least one metallic structure and a second position in which said actuator member operably engages said at least one metallic structure.

42. A microelectromechanical device according to Claim 35 wherein said microactuator is comprised of single crystalline silicon.

43. A microelectromechanical device according to Claim 35 wherein said at least one metallic structure is comprised at least one of nickel and gold.

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